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ABSTRACT

This paper reports on the findings of a longitudinal study that investigated the trends in reading growth for 49 elementary students with severe reading difficulties. The students received special education services in a large Midwestern city in which curriculum-based measurement (CBM) procedures were implemented fully. The study began when the children were in second grade and evaluated their performance on a standard oral reading passage for 4 years. A polynomial regression analysis was conducted to investigate the characteristics of the longitudinal growth pattern and the similarities between longitudinal and cross-sectional growth patterns. The presence of heterogeneous reading trends was examined by multi-level analysis using structural equation modeling. Results indicated that the linear growth pattern from the longitudinal data set was similar to the growth patterns derived from the four cross-sectional data sets. Then, under the presence of heterogeneity and auto-correlation in measurement error, the inter-individual differences in the rate of change were found. The findings confirm the feasibility of using the standard oral task to measure reading proficiency and of identifying children with severe reading problems beginning in relatively early grade levels. (Contains 26 references.) (Author/CR)

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Specification of Growth Model and Inter-individual Differences for Students with Severe Reading Difficulties: A Case of CBM

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Running Head: SPECIFICATION OF GROWTH MODEL

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Abstract

The trends of reading growth for elementary students with severe reading difficulties who received special education services in a large midwestern city district were studied using performance on a standard oral reading passage for four years. A longitudinal cohort consisting of 49 school-identified students with reading disabilities, participated in the first year of the study at grade 2. A polynomial regression analysis was conducted to investigate the characteristics of the longitudinal growth pattern and the similarities between longitudinal and cross-sectional growth patterns. The presence of heterogeneous reading trends was examined by multi-level analysis using structural equation modeling. Results indicated that the linear growth pattern from the longitudinal data set was similar to the growth patterns derived from the four cross-sectional data sets. Then, under the presence of heterogeneity and auto-correlation in measurement error, the inter-individual differences in the rate of change (slope) were found. Implications of utilizing the reading growth patterns for intervention and evaluation were also discussed.

Specification of Growth Model and Inter-individual Differences for Students with Severe Reading Difficulties: A Case of CBM

Since conventional intelligence and achievement testing are based, not on standard units (i.e., number or duration), but on the relative standing of an individual compared to peers, they say little about what a student can do on a functionally important task and tend to be relatively insensitive to real performance change over time.

Partly based on applied behavior analysis methodology, Curriculum-Based Measurement (CBM) is one of alternative assessments proposed in the academic skills of students with learning disabilities (Deno, 1985). The standardized procedures of CBM have proven to be a reliable and valid indicator of student performance in reading(Fuchs, Fuchs, & Maxwell, 1988). The CBM system approaches the absolute-unit-measurement (number of words read correctly), and provides the teacher with an efficient recording of the change in a child's academic skill.

An estimate of the developmental trend across grade levels has been provided by several developmental studies using passages of one difficulty level. A normative study reported by Deno, Marston, Mirkin, Lowry, Sindelar, and Jenkins (1982) produced a strong linear trend in the number of words read correctly (WRC) from a third grade passage across six grade levels in Fall, Winter, and Spring. The larger increases occurred in Grade 1-3 (around 40 words read correctly from one grade to the next). After Grade 3 the growth rate decreased to about 15 words read correctly per grade level. Another study using a third grade level passage from general education sample showed similar results (Marston, Lowry, Deno, & Mirkin, 1981). The yearly difference from Grades 1 to 2 was approximately 80 words read correctly, and around 15 WRC from Grades 2 to 6.

To describe the normative performance of reading using a standard oral reading task (the third grade passage) for a general education sample, Doss and Deno (1987) conducted an aggregated analyses on the number of words read correctly, collected at the end of school year from six administrative units. Deceleration in the curve of WRC started from the second grade (four administrative units) or the third grade (two administrative units). In the aggregated grade norms, the difference between grade 1 and grade 2 was 58 WRC. For grades 2 to 6, a constant increase (about 20 words per grade level) was reported.

The purpose of a developmental study is the examination of phenomena in their time-related constancy and change. As conceptualized by psychologists (Baltes, Reese, & Nesselroade, 1988; Schaie, 1965; Schaie & Baltes, 1975; Wohlwill, 1973), the study of

development can be characterized by at least two features.

First, the developmental study of behavior requires a concern with behavioral change and various patterns. In research design terminology, this concern can be translated into the study of intra-individual change and inter-individual patterns of intra-individual change (Baltes & Nesselroade, 1979; Buss, 1979). Second, the developmental study of behavior is oriented toward both description and explanation as necessary ingredients for knowledge about a given phenomenon. Thus, concern goes beyond examination of the questions "what?" and "when?" to considerations of "how?" and "why?". The descriptive task is aimed at identifying the nature (form, sequence, patterning) of behavioral development and the explanatory task involves searching for underlying mechanisms and determining causes of development. The traditional developmental approach has focused on a direct identification of within-entity (individual) change, which in turn is conceived of as being age-related. Such a viewpoint follows the paradigm B=f(A), where B refers to behavior, A to chronological age and f to a functional relation between both (Baltes, 1968; Schaie, 1965).

In this B=f(A) paradigm, chronological age appears to be viewed as a dimension along which change is plotted (Wohlwill, 1973), as an independent variable (J. Terwilliger, personal communication, 1993). The status of chronological age (or grade level) disqualifies it from being a full-fledged experimental variable. That is, age of subjects is an assigned variable that cannot be arbitrarily varied and replicated on the level of individual units. The research cannot make a student be a certain age; he or she can only wait until the student attains that age. Accordingly, it is important to realize that B=f(A) designs are usually of the preexperimental type (Campbell & Stanley, 1963). However, this simple B=f(A) design can be expanded to include additional treatment parameters and control arrangements (Baltes et al., 1988).

The identification and explanation of age functions (indexing change) become the critical objectives in the descriptive study. The two conventional designs used for the examination of an age-functional relationship are generally known as the longitudinal and cross-sectional methods. The longitudinal method follows the same person through all age levels with repeated observations. The cross-sectional method compares different age groups observed at one point in time (Baltes, 1968; Baltes & Reinert, 1969). Comparing the two designs in terms of objectives of the descriptive developmental study is as follows (Baltes & Nesselroade, 1979; Schaie & Baltes, 1975):

The first objective pertains primarily to the identification of intra-individual change and stability. This objective stipulates that the only direct method for identifying intra-individual change is to observe the same entity (e.g., individual) repeatedly--longitudinal method.

Change, constancy, and process extend through time; thus, static observation through the cross-sectional method does not provide the data base necessary for developing representations of the behavior. Identification of intra-individual change is the foundation of developmental research (Baltes et al., 1988). Basically, the cross-sectional method is not a direct approach to the study of intra-individual change. Under limiting conditions, the cross-sectional method can be used to examine "average" growth function, which is, however, open to empirical examinations.

Another objective of the descriptive developmental study is a direct identification of inter-individual differences and similarities in intra-individual change. The central question concerns the degree of homogeneity displayed by units as they develop (i.e., the degree of similarity in the course of intra-individual change shown by different individuals).

Differences or similarities in intra-individual change can be examined through the longitudinal method. After obtaining intra-individual change data, it is possible to examine inter-individual differences by comparing growth functions among individuals. In the absence of longitudinal data, the question as to whether group-average data adequately represent the individuals has been raised frequently in the literature (Baltes & Nesselroade, 1979). A growth curve based on cross-sectional group means is a very poor description of the actual course of growth seen in any given child (Bock, 1991). The growth model should be cross-validated by individual growth patterns based on the data from the longitudinal studies. The group-based approach, from the cross-sectional studies, poses many difficulties. One major problem is "averaging of results" or obscuring individual outcomes in one representative group average (Barlow & Hersen, 1984). Complexities of the group limit the usefulness of one and only representative group-average data.

Previous studies based on the cross-sectional data sets(Marston & Magnusson, 1988) showed that, in program evaluation using a CBM reading measure, the pattern of academic growth of regular education students is quite different from that of students who are referred to Learning Disabilities (LD) Programs across grade levels. However, there are some questions to be examined about normative growth of students with LD based upon the cross-sectional studies. In the longitudinal study proposed here, the characteristics of academic growth of LD will be examined for individuals as well as for a group. Especially, the research questions are as follows:

1. Does the growth trend derived from cross-sectional data match the growth trend from longitudinal data? What kind of growth model fit for the data set?
2. Does inter-individual differences in reading growth exist?

    2-1 Testing various assumptions of measurement errors in growth data

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Model 1: homoscedasticity and no auto-correlation

Model 2: heteroscedasticity and no auto-correlation

Model 3: heteroscedasticity and auto-correlation

2-2 Testing intercepts and slopes.

Method

Subject/Settings

The subjects in this study were from a district of a large midwestern city in which the CBM procedures were implemented fully. All of the subjects had an Reading Individual Education Plan (Reading IEP). The procedures for identifying students for special education services in this school district have been described in detail elsewhere (Marston & Magnusson, 1987). In general, students who are referred are extensively screened using the CBM procedures. The students placed in special education are those who function at least two grade levels below their age/grade placement on the CBM measures, and who have been determined by their IEP team to have special education needs

There were two different data collection activities: longitudinal and cross-sectional. The longitudinal cohort in this four year investigation was collected at the first year of the study when the subjects were second graders (39 boys and 10 girls; 30 African-Americans and 19 Caucasians). For the cross-sectional data sets, data for all of the reported students with LD of the school district in grades 2 to 5 were collected every year for a 4-year period. This investigation was based on an on-going effort to collect district-wide data for program evaluation (see Marston & Magnusson, 1987).

Materials

The primary testing material was a third-grade passage selected from the students' basal reading series, Ginn 720, Rainbow Edition (Clymer & Fenn, 1979). The passage possessed the following characteristics.

Length: 303 syllables/248 words/21 sentences

Word size: 52 of six or more letters/3 of three or more syllables

/average letters per word=4/average syllables per word=1.2

Readability: Fry= Grade 3

The test-retest reliability coefficient for a 10 week-period, collected in the first year, was .91.

Along with this common Ginn passage, in the first year, students had passages drawn from that students' grade appropriate reader (i.e., a second-grade student read from a second grade passage, see Appendix A). These grade-appropriate passages came from Holt Reading Series (Weiss, Steurer, Crunickshank, & Hunt, 1983). The district curriculum specialists

developed, with permission from the publisher, a package to be used by all special education resource teachers (SERT). Marston (1989) reported that the test-retest reliability coefficient (10 week period) for the grade level passages was .82.

Administration and Scoring

The subjects completed the reading task as part of a district-wide program evaluation process. Data collection was done once each school year. Data of the common passage were collected in the spring (first week of May) by special education resource teachers (SERT). The standardized directions and scoring procedures proposed by Deno, Mirkin, and Wesson (1984) were employed. Words were counted as correct if they were pronounced correctly. An error was scored when a word was mispronounced, omitted, or substituted. Words pronounced incorrectly but self-corrected with 3 seconds were scored as correct. Repetitions and insertions were not counted as errors. When students took longer than 3 seconds to read a word, SERTs supplied the correct word and counted an error. The number of words read correctly from the common passage and the grade-appropriate passages was served as the dependent measure for this study. In both of the tasks, a teacher and a student copy of passage were provided to SERTs. The number of words was totaled cumulatively to the right of each line on the teacher copy; student copies were unnumbered.

Training

Data collectors were SERTs in the district. They were trained in administration and scoring of the CBM measures in 2 half-day workshops before the study began. The training is designed to educate SERTs on the philosophy and research behind CBM, followed by extensive experience in administration and scoring. Intraobserver agreement estimates exceeded .90 (see Marston & Magnusson, 1985).

Analyses

First, in order to determine the group trend, polynomial regression analysis was used to test linearity or curvilinearity. Overall and partial test statistics provided the level of significance of a linear, quadratic, and cubic effect coefficients. Cross-validation of the regression equation derived from the longitudinal data set was conducted for the cross-sectional data sets. Second, to investigate inter-individual differences in reading growth, multi-level analysis scheme was applied. Especially, structural equation modeling was adopted to test various assumptions of measurement errors in growth data (Bentler, 1992; Muthen, 1991; Willett & Sayer, 1993).

Results

In Table 1, descriptive results for the number of words read correctly (WRC) from the Ginn common passage (CP) are presented for each grade level (grades 2 to 5) and data set

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(one longitudinal and four cross-sectional data sets). The mean number of WRC increased across successive grade levels in all data sets.

Insert Table 1 about here

The trends in reading words correctly are shown in Figure 1. Figure 1 graphically portrays the means for reading performance. To illustrate the mean performance by general education students, the grade norms for the same measure reported by Doss and Deno (1987) is also presented. The growth trend for students with reading difficulties as well as general education students was roughly linear without dramatic positive or negative acceleration. The rate of increase was approximately 20 words per year. The means of longitudinal data set were lower than those of all cross-sectional data sets in Grades 2 and 3. Then, the longitudinal trend approached the cross-sectional trends for Grades 4 and 5.

Insert Figure 1 about here

A stepwise polynomial regression analysis method was used to find the characteristics of a trend in reading growth (Table 2). In this regression analysis, the level of significance adopted for entry of regression equation was .15. This reflected a concern about committing a type II error. The use of a numerically large probability value (i.e., .10 or .15) increases the power of the test if the null hypothesis is false. The higher criterion may allows a term to enter into the equation without strong statistical significance. This criterion was established to avoid a model specification error. The overall F-test was significant. Only the linear term was statistically significant. To cross-validate the regression model established from the longitudinal data set, the same equation was applied to the four cross-sectional data sets. The correlation coefficients between the predicted variable from the equation and the observed variable (comparable to multiple R) were calculated. Although these coefficients were lower than the multiple R in Table 2, they are statistically significant ($p<.01$) and stable (.68, .70, .70, and .71).

Insert Table 2 about here

After the linearity of the growth trend was identified, the more sophisticated analysis on the longitudinal dataset was conducted. Especially, intra-individual changes and inter-individual differences were examined under the various assumptions of measurement

errors. To test the homoscedasticity and autocorrelation of measurement errors between the adjacent time points, three models were proposed.

Model 1: homoscedasticity and no auto-correlation

Model 2: heteroscedasticity and no auto-correlation

Model 3: heteroscedasticity and auto-correlation

In Table 3, although the χ^2 statistics was a little large, given its degree of freedom (χ^2=11.52, df=2), only the value of Comparative Fit Index (CFI) of Model 3 was acceptable (.90). Thus, the maximum likelihood estimates of the parameters of Model 3 were adopted. The entries in the first two rows of Table 3 for Model 3 estimated the population means of true intercept (14.42, $p<.001$) and true slope (22.92, $p<.001$), and described the average trend of true change in WRC. On average, WRC increased by 22.92 per year, having a value of 14.42 at Grade 2. The entries of the third and fourth rows for Model 3 estimated population inter-individual heterogeneity in true change. Because both of these variances (205.92, $p<.05$; 60.91, $p<.05$) were non-zero, between-person heterogeneity at Grade 2 and rate of change in WRC existed. The fifth table entry provided an estimate of the covariance of true intercept and true rate of change in WRC across students (-98.63, $p<.05$). From this information, the correlation between slope and intercept was negative, which indicated that the student with higher level of WRC at Grade 2 also had the most rapid rates of increase. The entries in the sixth through ninth rows provided estimates of measurement error variance. Finally, the entries in the tenth through twelfth rows indicated the existence of pair-wise auto-correlation.

Insert Table 3 about here

Discussion and Implications

The trends of reading growth for elementary students with severe reading difficulties who received special education services in a large midwestern city district were studied using performance on a standard oral reading passage for four years. A longitudinal cohort consisting of 49 school-identified students with reading disabilities, participated in the first year of the study at grade 2. A polynomial regression analysis was conducted to investigate the characteristics of the longitudinal growth pattern and the similarities between longitudinal and cross-sectional growth patterns. Through the multi-level analysis scheme, the modeling of individual growth pattern was investigated. The structural equation modeling offers many flexibilities, including between- and within- individual growth analysis, detailed information on the overall goodness-of-fit of the hypothesized model, and explicit tests of

occasion-by-occasion measurement errors (auto-correlation and homoscedasticity). The longitudinal growth pattern seemed to match the growth patterns from cross-sectional sequential data sets. Furthermore, the trend turned out to be linear. The fitted model(Model 3) suggested that between-person heterogeneity in the intercept and slope exits and heteroscedasticity and auto-correlations in measurement errors should be included in the growth model.

Despite the clear linear trend found for the group, the results indicated that the group-level reading growth trend was unrepresentative of the growth for individual students. Diverse growth patterns, then, become heterogeneous feature of the group of students with severe reading disabilities classified as learning disabled. Because of the exclusion of most of the known forms of exceptionality, professionals in learning disabilities field have to conceptualize to specify exactly how learning disabilities is disabled. Some of more frequently cited characteristics that emerge from the literature include perceptual-motor impairment, disorders of attention, poor motivation, language problems, and so on (McKinney, 1984). These characteristics of the conceptual definition result in making contributions to the most explicit feature of learning disabilities -- heterogeneity.

The heterogeneity also becomes clear in the basic premise for the operational definition of learning disabilities for identification, such as developmental discrepancy. Learning disabilities has often been identified through the way it is differentiated from normal development by a discrepancy between what development allows (Parrill, 1987). Reading disability is the category in which differentiation of delayed development from the normal development is based on a achievement dimension (reading). Delayed development of reading refers to the kind of development where milestones are accomplished at a slower rate than they are in normal development. The results of the present study showed not only the delayed development of reading proficiency but also the heterogeneity in developmental trends for students with reading disabilities.

Several limitations affecting both the internal and external validity of the present study need to be identified. First, this investigation was, of necessity, descriptive. Speculation on the underlying mechanisms and determination causes of development were not appropriate under the design of the present study, because of lack of control over significant variables in student learning. Second, the description of students with reading disabilities was focused on differentiation of delayed reading development based upon a single dimension -- number of words read aloud from text. Thus "delayed" development in the present study was limited to that performance indicator and we cannot be sure that all reading achievements was delayed. Since oral reading correlates highly with other measures of reading Fuchs, Fuchs, & Maxwell,

1988), the results were noteworthy. Finally, the problems of the longitudinal data required attention. Especially, attrition rate and inclusion of few relevant variables due to high cost in a long-term study often limit the generalizability of most of the longitudinal studies. In order to overcome the longitudinal data with limited information, McArdle and Hamagami (1991) proposed new methodological insight: the simultaneous use of cross-sectional and longitudinal data to provide a basis for drawing inferences about individual change, differences representing historical influences, and effects produced by repeated measurements. With reasonable substantive theory, they showed a possibility of a mixture of cross-sectional and longitudinal data and methods within multiple-group structural equation modeling. The different strengths of cross-sectional and longitudinal gatherings of data can provide a sound basis for inference about individual change.

Although the present study was limited in some respects, it did add to the current literature regarding the academic development for students with reading difficulties within CBM system. The present study confirmed the feasibility of using the standard oral task to measure reading proficiency. When a common task (third grade level) is used across elementary grades, whether the common task can discriminate among children with reading difficulties is a empirical question due to plausible floor effects. The results of this investigation indicate that the standard oral reading measure can be used to discriminate students with severe reading problems beginning in relatively early grade levels. Special education teachers may use this measure to get a snapshot of the target student's reading performance in line with developmental status. The next step will be a systematic investigation on the variables which explain inter-individual differences of slope.

In conjunction with reading development models, the reading trends of the present study may guide developmentally relevant reading intervention. The reading development is viewed as the criteria, by which effective reading instruction can be implemented in order to provide students with appropriate reading skills and strategies. Below the appropriate level in fluency, decoding is still an important task to master, without which the transition to reading comprehension can be obstructed. The initial performance of the students with reading difficulties seems to influence their progress over elementary years. However, it does not necessarily mean that these students are doomed to failure. The present study showed that the students' growth in reading proficiency was evident across grade levels, whether the increases are small or large. Undoubtedly, one major factor making a contribution to their progress was their schooling -- special reading instruction. In a way, the results of the present investigation refine the age-old maxim that teaching students with severe reading difficulties should take into consideration their developmental statuses.

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Table 1

Mean and Standard Deviation of Numbers of Words Read Correctly

Type of Data set		Grade 2	3	4	5
Longitudinal	M	14.23	31.49	60.22	80.57
	SD	8.50	18.34	28.41	26.48
Cross-sectional					
Year 1	M	19.94	36.81	55.69	78.11
	SD	14.58	24.07	25.85	31.76
		(189)	(145)	(148)	(195)
Year 2	M	19.65	38.15	58.10	81.91
	SD	16.68	21.83	28.08	29.71
		(223)	(150)	(138)	(130)
Year 3	M	19.76	42.13	63.95	83.90
	SD	17.25	24.90	27.48	30.82
		(224)	(181)	(157)	(163)
Year 4	M	23.64	47.44	61.80	84.57
	SD	14.80	23.77	22.23	28.14
		(279)	(228)	(186)	(172)

Note. Numbers of students are in the parentheses.

Table 2

Polynomial Regression Results: Number of Words Read Correctly (WRC)

Multiple R	.76		
R^2	.58		
Adjusted R^2	.58		
Overall F-test	2251.30 ***		
Dubin-Watson Test	1.84		
	Unstandardized Coefficient	**Standardized Coefficient**	**t**
Variables in the Equation			
Linear	21.60(1.36)	.76	15.85 ***
Constant	-12.83(3.88)		
Variables not in the Equation			
Quadratic		.10	-.35 [a]
Cubic		.01	-.08 [a]

a $p > .70$

*** $p < .001$

Table 3

Fitted models demonstrating inter-individual differences in change: Testing homoscedasticity and auto-correlation.

Parameter	Model 1	Model 2	Model 3
μ_{π_0}	12.13***	13.70***	14.42***
μ_{π_1}	24.00***	23.78***	22.92***
$\sigma^2_{\pi_0}$	23.56	54.55***	205.92*
$\sigma^2_{\pi_1}$	43.40***	62.47***	60.91*
$\sigma_{\pi_0\pi_1}$	71.06***	29.94**	-98.63*
$\sigma^2_{\epsilon_1}$	156.03***	.00	.00
$\sigma^2_{\epsilon_2}$	156.03***	183.03***	229.59***
$\sigma^2_{\epsilon_3}$	156.03***	246.24***	330.19*
$\sigma^2_{\epsilon_4}$	156.03***	107.21	37.57
$\sigma_{\epsilon_1\epsilon_2}$			26.34
$\sigma_{\epsilon_2\epsilon_3}$			84.34*
$\sigma_{\epsilon_3\epsilon_4}$			43.55
χ^2	58.09	19.32	11.52
df	8	5	2
CFI	.49	.85	.90

*p<.05 **p<.01 ***p<.001

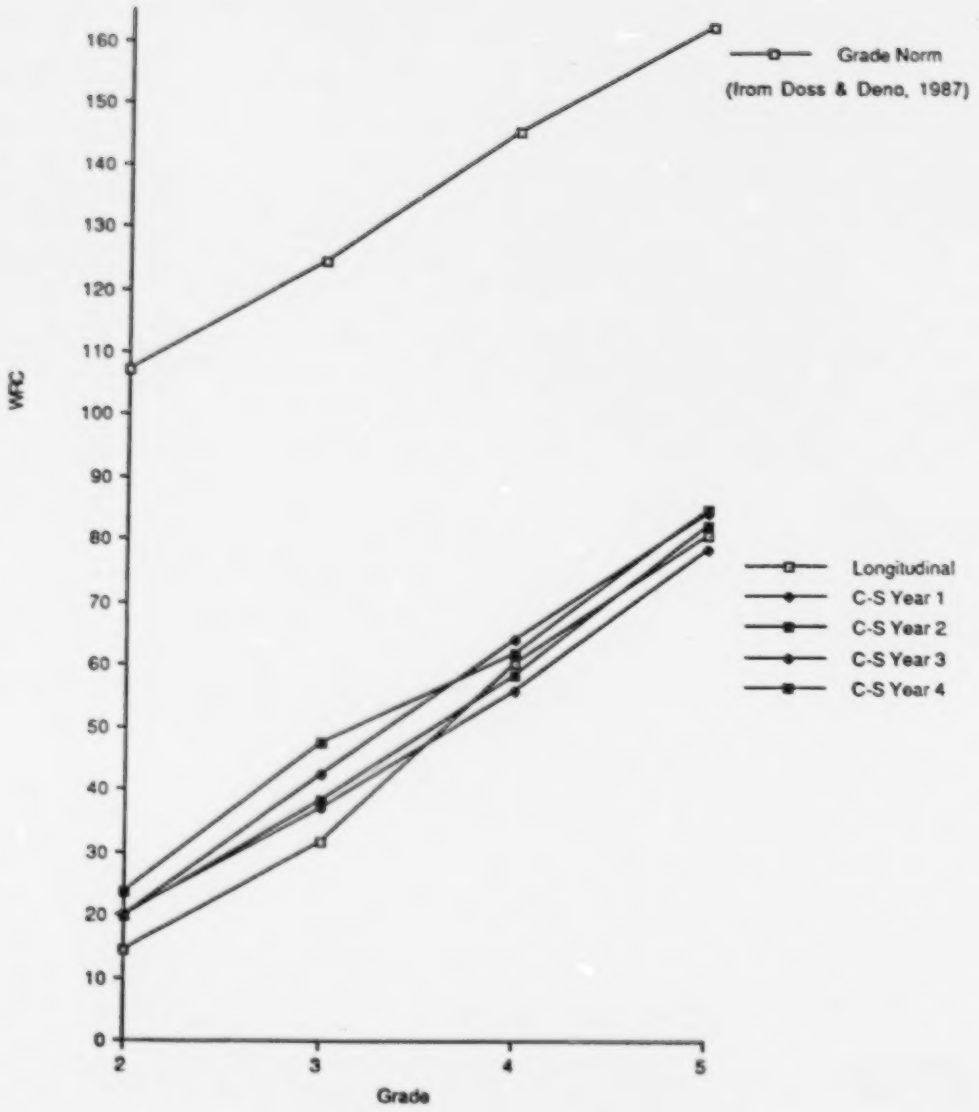

Figure 1. Mean Numbers of Word Read Correctly for Different Data Sets

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